COMPARATIVE ANALYSIS OF ARMENIAN COMMERCIAL BANKS' PERFORMANCE

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Key words: Pythagorean fuzzy set, fuzzification, defuzzification, triangular and trapezoidal functions

Introduction The efficiency of the banking system is significant for ensuring the country's economic development and stability, both in developed and developing countries. It is well known fact that financial crises usually are the result of the instability and inefficiency of the banking system. Studying the factors for the assessment of the instability of the banking system allows to determine characteristic trends of the stability of the banking system. Therefore, the problem of studying the effective functioning of the banking system is emphasized and methods and approaches are proposed, which give an opportunity to evaluate factors with negative financial and economic effects, as well their manifestations and behavior.

Literature review Among the researches in this direction it is worth to mention the study of Zha, N. Liang, M. Wu, and Y. Bian [Zha, et al., 2016, 60–72] . The authors studied the problems arising in the conditions of economic globalization and identified the factors influencing the efficient operation of banks, as well as the phenomena determining the financial instability cha-racteristic of the competitive environment. In line with the studies of the mentioned authors there is another one by Y. Wooluru, D. R. Swamy, and P. Nagesh [Wooluru, et al.,, 2014, 399-416]. The researches revealed the features of the efficient operation of banks contributing to economic development. The assessment of the bank's activity is characterized by the fact that the effectiveness of the management process of cooperation with both internal and external clients is considered. The research implemented by European Journal of Operational Research [EJOR, 2016, 280-295]. The authors evaluated the performance of Chines banks through the study and comparative analysis of banks indicators and proposed a modeling approach, applying the method of fuzzy sets created by L. A. Zadeh [Zadeh, 1975, 199–249]. The next study [Zimmermann, 2001] is devoted to the study of the banking pro-cess under conditions of uncertainty by modulating fuzzy sets [Klir & Folger, 1988]. The authors proposed a model of the bank's activities under uncertainty using fuzzy set methods.

Scientific novelty Bank performance measurement is one of hot debated issues in financial sector. Based on the requirements and features of financial systems and in

particular banking, we note that banks generally differ from one another. The study of banking orientation shows that the activities of banks are associated with uncertainty, risks, and therefore banks are actively looking for effective methods and opportunities for organizing activities. The method of using fuzzy sets especially Pythagorean fuzzy sets has not been used by researchers for evaluating Armenian commercial banks performance. The research concludes that using fuzzy sets can be one of the tools for comparing banks efficiency and evaluating banks performance.

Methodology: *The Pythagorean approach to fuzzy sets* The studies [Parvathi, 2016, 1211-1227] and [Radhika, 2016, 19-26.] are significant contribution in the theory of fuzzy sets. The authors proposed an approach based on a new definition of fuzzification and defuzzification through the presentation of Pythagorean fuzzification and defuzzification functions [Jayapriya & Sophia, 2021, 286-290] are given.

Definition 1: Let X is a given universal set. Let's define $A=\{(x,\mu_A(x),\nu_A(x):x\in X\}$, where $\mu_A(x),\nu_A(x)$ represent the set on the segment [0,1], and express the degree of belonging or non-belonging from any $x\in X$ and $0\le\mu_A(x)+\nu_A(x)\le 1$.

Definition 2: Let's suppose M is a given fixed set. The fuzzy Pythagorean set in M can be represented as follows $P=\{(m,\lambda_P(m),\eta_P(m)):m\in M\}$,

where $\lambda_P(m),\eta_P(m)$ represents the set M on the segment [0,1], $0\le\lambda_P(m)\le 1,0\le\eta_P(m)$ and $\lambda_P^2(m)+\eta_P^2(m)\le 1,\ m\in M$ express the degree of belonging or not belonging to the P for he element $m\in M$, respectively.

Definition 3: Let $\pi_P(m)=\sqrt{1-\lambda_P^2(m)-\eta_P^2(m)},$ and it will be called as fuzzy index of P and represents the degree of uncertainty of $m\in M$ in terms of P ; $0\le\pi_P(m)\le 1,m\in M$.

According to V. Jayapriya and R. Sophia Porchelvi <Pythagorean fuzzification and defuzzification functions>, Malaya Journal of Matematik, Vol. 9, No. 1, 286-290, the vague triangular Pythagorean function is defined as follows.

Definition 4:

$$\lambda_{APF}(x)=\begin{cases}0 & : x\le a_1\\ \sqrt{\dfrac{x-a_1}{a_2-a_1}-\varepsilon^2} & : a_1\le x\le a_2\\ \sqrt{\dfrac{a_3-x}{a_3-a_2}-\varepsilon^2} & : a_2\le x\le a_3\\ 0 & : x\ge a_3\end{cases} \qquad (1)$$

where $a_1 \le a_2 \le a_3$. A triangle is defines by determining the parameters a_1, a_2, a_3 where a_1, a_3 corresponds to the base of the triangle and a_2 corresponds to the vertex of the triangle.

Definition 5: The fuzzy Pythagorean tabular function is determined as follows.

$$\lambda_{APF}(x) = \begin{cases} 0 \ : \ x \le a_1 \\ \sqrt{\dfrac{x-a_1}{a_2-a_1} - \varepsilon^2} \ : \ a_1 \prec x \le a_2 \\ \sqrt{1-\varepsilon^2} \ : \ a_2 \le x \le a_3 \\ \sqrt{\dfrac{a_4-x}{a_4-a_3}} - \varepsilon^2 \ : \ a_3 \le x \prec a_4 \\ 0 \ : \ x \ge a_4 \end{cases} \qquad (2)$$

Lets suppose that X time series is given and a_1, a_2, a_3 are determined as follows: a_1 is a minimal value, a_3 the maximum value and a_2 is the median of value of the time series X . It follows that the expression under the root of equation $\sqrt{\dfrac{x-a_1}{a_2-a_1} - \varepsilon^2}$ (1) will get negative values in case $x = a_1$.

The same remark applies to the expression $\sqrt{\dfrac{a_3-x}{a_3-a_2} - \varepsilon^2}$.

Consequently definitions of fuzzy function (1) and (2) should be improved as follows by eliminating the negativity of the radical expression.

$$\mu_A(x) = \begin{cases} 0 \ : \ x \le a_1 \\ \sqrt{\dfrac{x-a_1}{a_2-a_1} - \varepsilon^2} \ : \ a_1 \prec x \le a_2 \\ \sqrt{\dfrac{a_3-x}{a_3-a_2} - \varepsilon^2} \ : \ a_2 \prec x \prec a_3 \\ 0 \ : \ x \ge a_3 \end{cases} \qquad (3)$$

Let us assume that X time series is sorted in ascending order. Define $A = \{(x, \mu_A(x) : x \in X\}$, where $\mu_A(x)$ is fuzzy function (3) defined on the set X and $0 \le \mu_A(x) \le 1$.

The defuzzification function

Suppose that $a_1 = \min x : x \in X$, a_2 is the median of the sat X , $a_3 = \max x : x \in X$: Let us denote

$\overline{X}_1 = \{x \in X : x \le a_1\}, \overline{X}_2 = \{x \in X : a_1 < x \le a_2\}, \overline{X}_3 = \{x \in X : a_2 < x < a_3\}$,

$\overline{X}_4 = \{x \in X : a_3 \le x\}$:

$X_1 = \overline{X}_1 \bigcup \overline{X}_2$, $X_2 = \overline{X}_3 \bigcup \overline{X}_4$, $X_3 = X_1 \bigcup X_2$.

Thus, denote

1. $\mu_i(x) = \mu_A(x), x \in X_i, i = 1,2,3$,
2. $\delta_i(x) = x * \mu_i(x), x \in X_i, i = 1,2,3,$
3. $M_i(X_i) = \sum_{x \in X_i} \mu_i(x), i = 1,2,3$ (4)
4. $D_i(X_i) = \sum_{x \in X_i} \delta_i(x), i = 1,2,3$
5. $\alpha_i = D_i(X_i) / M_i(X_i), i = 1,2,3.$

Thus, we will define the Pythagorean defuzification index as follows.

1. Let us define the set of banks as $N = \{1,2,...i,...,n\}$,
2. Let us denote a set of quarters as $E = \{1,2,..., j,...,m\}$,
3. Let us denote denote the value the of the activity indicator of the i-th bank for the j-th quarter as $x_{ij}, i = 1,2,...,n, j = 1,2,...,m$:
4. Let us denote the fuzzy function assessing the efficiency of the bank's activity as $\mu_i(x) = \mu_A(x), x \in X_i, i = 1,2,3,4$:

Let us denote defuzzy indices of the assessment of the efficiency of the bank's activity as $\alpha_i = D_i(X_i) / M_i(X_i), i = 1,2,3.$

Bank performance evaluation indicators The condition of uncertainty is the feature of bank's activity as noted in [N. Y. Sec¸me, A. Bayrakdaro˘glu, and C. Kahraman, pp. 11699–11709, 2009.] and [A. T. Gumus, pp. 4067–4074, 2009]. Authors of this research considered the method of fuzzy set for the assessment of bank performance. Following of this research and based on the trigono-metric representation of fuzzy set given in [D. Tadi´c, M. Stefanovi´c, and A. Aleksi´c, pp. 2091–2101, 2014] we implemented the method of Pythagoren fuzzy set for the comparative analysis of Armenian banks. Thus, we consider fuzzy function and defuzzufication given in definition (4).

Problem setting For the comparative analysis of the performance of the banks, the time series of the ROA indicator of the banks are considered, presenting them in ascending order, obtaining a vague trigonometric image according to formula (4) and the boundaries, where the vertex of the triangle corresponds to the vague estimate corresponding to the median of the time series (if the series has odd terms/ or the numerical average of the average of two values /if the series has an even term).

Lets denote the set of banks as $N = \{1,2,...i,...,17\}$, and the set of quarters of factors as $E = \{1,2,..., j,...,m\}$: Lets make a non-specification by applying formula (4).

Table 1. Banks defuzification indicators assessment

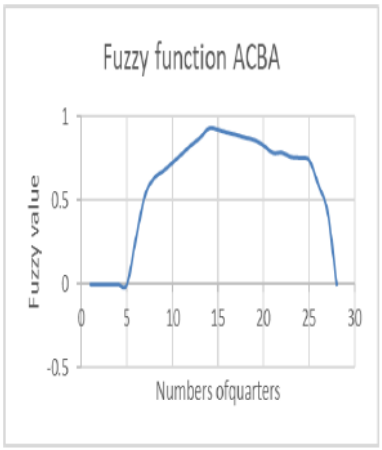
Bank's name	α_1	α_2	α_3
ACBA	0.84	1.89	1.49
ASHIB	0.95	1.98	1.47
America	1.86	1.84	1.48
ID	0.1	0.95	0.88
Ararat	0.92	2.21	1.6
ABB	0.51	0.7	0.64
AEB	0.13	0.31	0.25
ArmSwBank	3.26	4.2	3.68
Artsakhbank	1.21	2.7	2.4
VTB	(N/A)*	N/A	N/A
Byblosbank	N/A	N/A	N/A
Conversebank	2.79	2.11	4.38
Evocabank	1.91	2.31	1.82
HSBC	1.49	3.19	2.44
Inecobank	2.89	4.13	3.34
Unibank	0.29	1.02	0.71
MellatBank	1.65	3.2	2.41

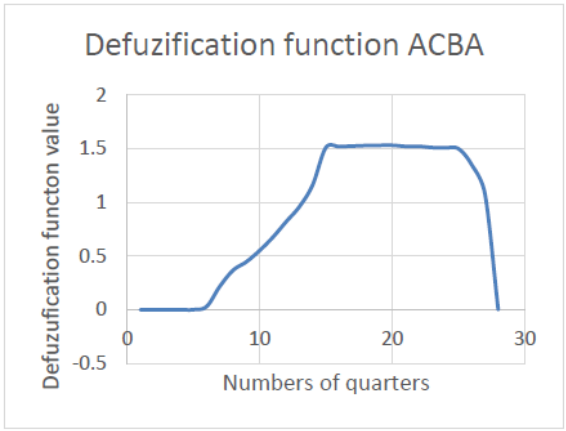
* Not adjustable

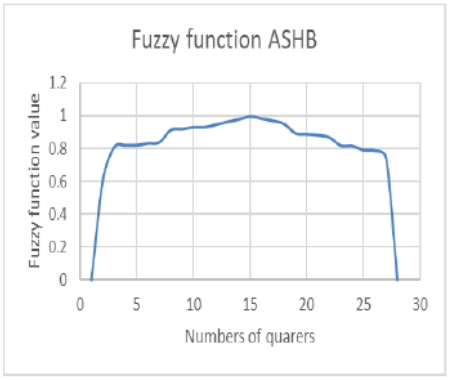
Conclusion Defuzzification indicators allows to implement comparative analysis of Armenian commercial banks using values of the indicator α_3. Banks ordering according to the value of α_3 is given in the table 2.

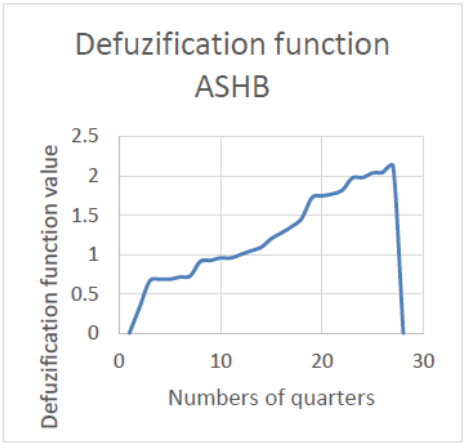
Table 2. Banks ordering according to the value of α_3

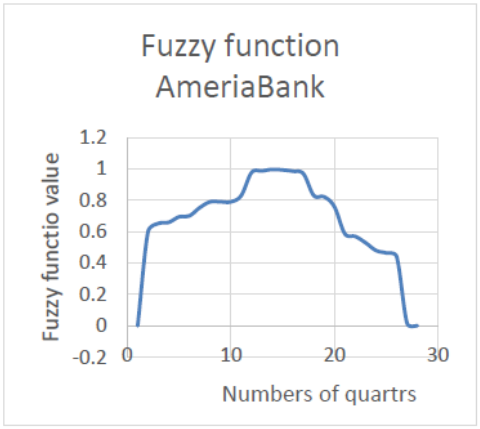
Bank's name	α_3
AEB	0,25
ABB	0,64
Unibank	0,71
ID	0,88
ASHIB	1,47
Ameria	1,48
ACBA	1,49
Ararat	1,6
Evocabank	1,82
Artsakhbank	2,4
MellatBank	2,41
HSBC	2,44
Inecobank	3,34
ArmSwBank	3,68
Conversebank	4,38
VTB	N/A
Byblosbank	N/A

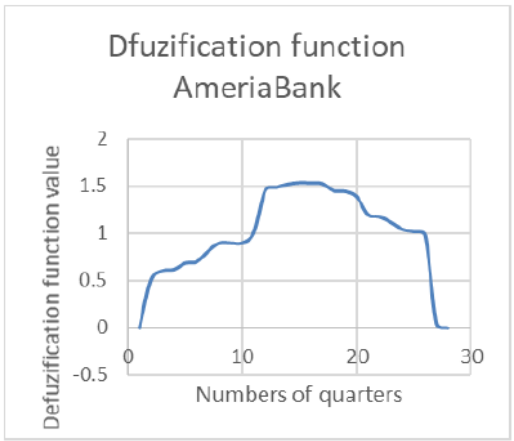

Fuzzy function ACBA
Fuzzy value
1
0.5
0
-0.5
0
5
10
15
20
25
30
Numbers ofquarters

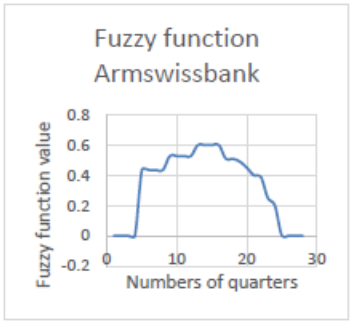

Defuzification function ACBA
Defuzufication functon value
2
1.5
1
0.5
0
-0.5
0
10
20
30
Numbers of quarters

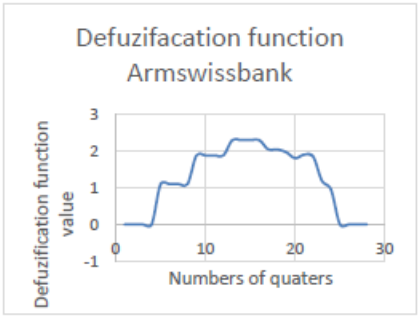

Fuzzy function ASHB
Fuzzy function value
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
Numbers of quarers

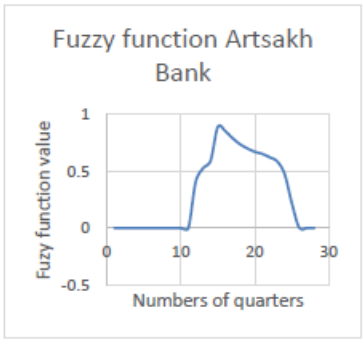

Defuzification function ASHB
Defuzification function value
2.5
2
1.5
1
0.5
0
0
10
20
30
Numbers of quarters

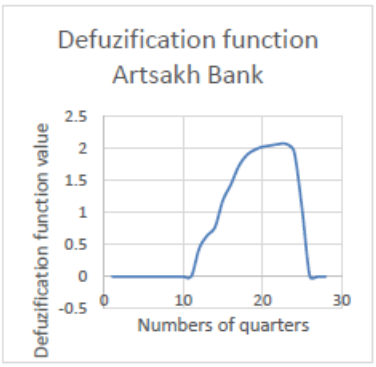

Fuzzy function AmeriaBank
Fuzzy functio value
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
Numbers of quartrs

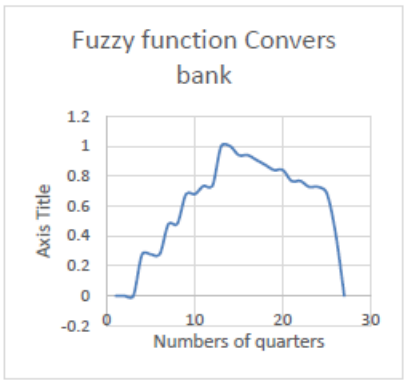

Dfuzification function AmeriaBank
Defuzification function value
2
1.5
1
0.5
0
-0.5
0
10
20
30
Numbers of quarters

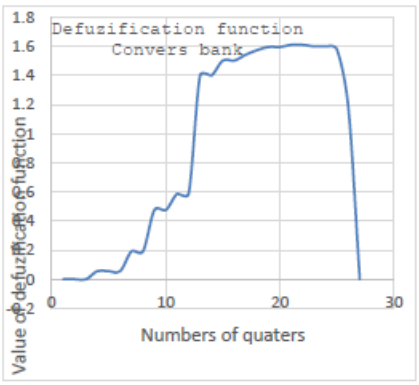

Fuzzy function Armswissbank
Fuzzy function value
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
Numbers of quarters

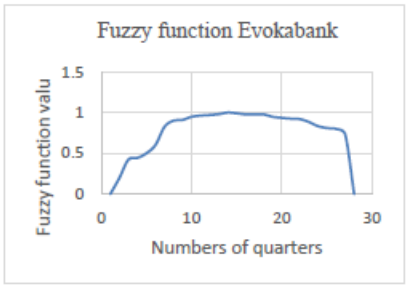

Defuzifacation function Armswissbank
Defuzification function value
3
2
1
0
-1
0
10
20
30
Numbers of quaters

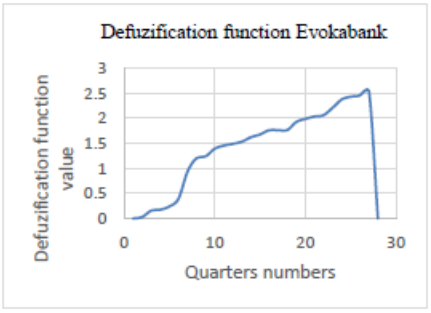

Fuzzy function Artsakh Bank
Fuzy function value
1
0.5
0
-0.5
0
10
20
30
Numbers of quarters

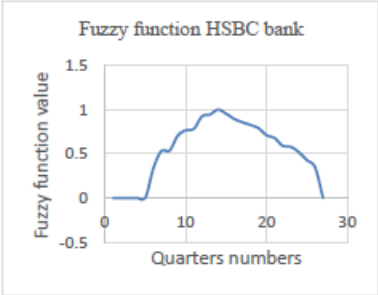

Defuzification function Artsakh Bank
Defuzification function value
2.5
2
1.5
1
0.5
0
-0.5
0
10
20
30
Numbers of quarters

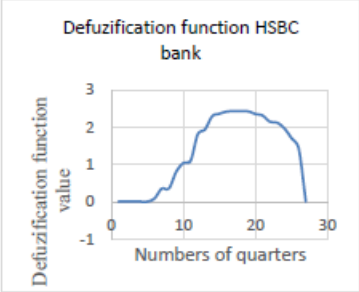

Fuzzy function Convers bank
Axis Title
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
Numbers of quarters

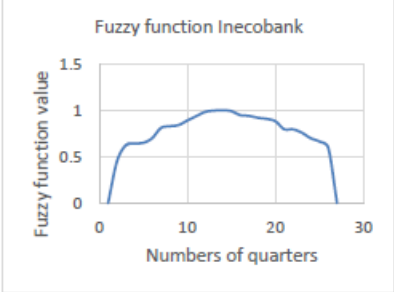

Defuzification function Convers bank
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
10
20
30
Numbers of quaters

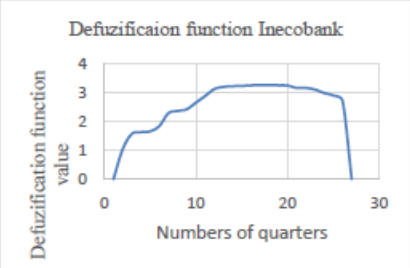

Fuzzy function Evokabank
Fuzzy function valu
1.5
1
0.5
0
0
10
20
30
Numbers of quarters

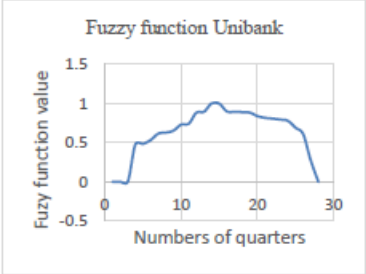

Defuzification function Evokabank
Defuzification function value
3
2.5
2
1.5
1
0.5
0
0
10
20
30
Quarters numbers

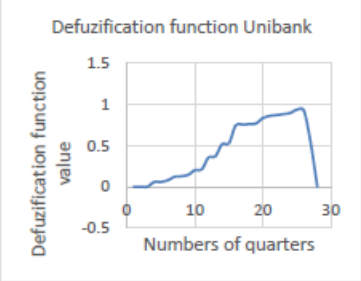


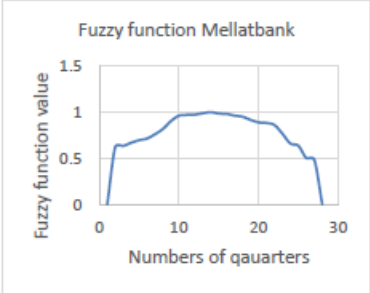


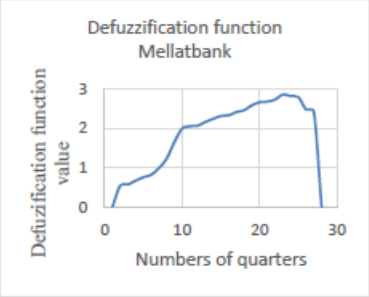












Summarizing above mentioned this paper proposes the modified Pythagorean fuzzifica-tion and defuzification method. Proposed approach of fuzification and defuzification is applied to the problem of comparative analyses of Armenian commercial banks as the application. The assessment of the degree of performance banks allows to get list of ranking of Armenian commercial banks.

We suggest that given schema of bank's activity performance assessment could be used for real economic or financial time series.

Conclusion This paper proposes the modified Pythagorean fuzzification and defuzification method. Proposed approach of fuzification and defuzification is applied to the problem of comparative analyses of Armenian commercial banks as the application. The assessment of the degree of performance banks allows to getlist of ranking of Armenian commercial banks.

We suggest that given schema of bank's activity performance assessment could be used for real economic or financial time series. Summarizing, the Pythagorean method refers to direct methods for constructing a membership function and, as a rule, allows measurements to be made on a quantitative scale. In particular, when using the method under study, it is enough to fix the most characteristic values and type of the membership function. We argue that the process of constructing or specifying a fuzzy set based on the Pythagorean membership function makes it possible to perform fuzification and bring the values of a measurable attribute to fuzziness in advance.

We also argue that the proposed approach applied to solving the problem of fuzification of variables characterizing the features of the bank's functioning expands the scope and capabilities of direct methods for constructing membership functions and fuzification of measurable features.

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Comparative analysis of Armenian commercial banks' performance

Key words: Pythagorean fuzzy set, fuzzification, defuzzification, triangular and trapezoidal functions

In order to get a tool for comparing banks efficiency, especially most efficient quarters the researchers suggest using fuzzy sets. For comparing various banks performances the time series of the ROA indicator of the banks are taken, presenting them in ascending order. A vague trigonometric image is obtained. Time series of seventeen Armenian banks quarterly ROA values has been analyzed. The concept of fuzzification and defuzzification is discussed in this paper. Crisp quantity is converted into a Pythagorean fuzzy set and respectively Pythagorean fuzzy set is converted into crisp quantity. After getting appropriate coefficients quarters have been classified into four groups from the more efficient to the less efficient. As a result it was possible to conclude when the banks were more efficient and when less. The method shows that is possible to use non regression new models for comparing and classifying banks performance determinants. It is a new approach in efficiency analyses.